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# Promising Tornado Warning Techniques

Dr. Donald R. Fitzgerald, Meteorological Research Laboratory, AFCRL

Two extremely promising techniques for improving the precision of tornado warnings were recently uncovered by AFCRL scientists during a series of U-2 flights in Oklahoma. The U-2 aircraft was specially instrumented for photographing cloud activity from above and for measuring electrical field disturbances. One of the techniques involves the simple visual observation from above of rapid changes in the circulation systems associated with large thunderheads. The other involves a distinct pattern of electric field disturbances associated with the development of a vortex circulation.

The study was conducted by Harold Klieforth who measured the wind, temperature, and turbulence fluctuations of the air streaming over the large storms, and by Donald Fitzgerald who measured the development of electric charge and lightning patterns associated with the storm.

Of special interest was the development of the large "whirlpool" circulation in the cloud formation just downwind of a giant thunderstorm tower. Excellent photographs of this whirlpool circulation were taken. It is this circulation which seems to portend the birth of tornadoes. Continuous observations were made over the thunderhead as it developed for over an hour. At the time the vortex appeared the storm had reached an altitude of 54,000 feet and had a tower diameter of about 15 miles. The vortex photographed by the U-2 had a 40,000 foot diameter and a depth of about 10,000 feet.

Some 45 minutes following the appearance of this large vortex, several tornadoes were observed on the ground. The tornadoes appeared to lie in a straight path passing through the initial position of the vortex. This pathline was about 40 degrees to the right of the mean upper air flow.

When this particular vortex developed, the electric field, measured some 12,000 feet above the storm, began to fluctuate with a much higher frequency but with smaller amplitude lightning field changes than had occurred during the buildup of the thunderstorn tower. If a similar change in the amplitude and the number of sferic pulses from these storms is found to accompany the transformation of the storm into one with a large vortex circulation, and if these circulations are found systematically to precede formation of tornadoes at low altitudes, this information can be readily applied to tornado warning techniques. These promising techniques will be further investigated during the 1963 tornado season.

# AFCRL plans new SOLAR TELESCOPE

Dr. Richard Dunn
Sacramento Peak Solar Observatory, AFCRL

A new solar vacuum telescope to be built at the AFCRL Sacramento Peak Solar Observatory site in Sunspot, New Mexico, is planned by the Laboratories.

Design concepts for the telescope were established by AFCRL scientist, Dr. Richard Dunn. The unique telescope will have a total vertical length of 328 feet of which 200 feet will be beneath ground level. This basic configuration suggested by Dr. Dunn is subject to modification on the basis of the detailed engineering and design study to be conducted by Charles W. Jones Engineering of Los Angeles. The above-ground segment will rise 128 feet above the highest hilltop at AFCRL's existing Sacramento Peak Observatory, which is situated at an altitude of 9200 feet in the Sacramento Mountains in New Mexico. With the completion of the new telescope the Sacramento Peak Observatory, already a major solar research center, will become one of the most complete facilities in the world for the study of solar phenomena.

Plans call for the completion of the new telescope before the next period of maximum sunspot activity. Following a normal 11-year cycle, sunspot activity, presently low, will begin to increase in 1965, and will reach maximum intensity by 1970.

The new facility is closely linked to the Nation's space programs. Of prime concern, are high energy proton showers associated

with sunspot activities. These showers provide a great potential hazard to man in space, and degrade electronic equipment. The study of characteristic features on the surface of the sun giving rise to these showers will receive special emphasis. From these studies, AFCRL scientists hope to extend the period over which they can predict the onset of proton showers. Prediction at the present time can be made with considerable accuracy over a five-day period.

The exposed, above-ground portion of the telescope will consist of a truncated cone-shaped tower and associated laboratory buildings. Atop the tower will be a rotating turret for tracking the sun in elevation and azimuth. Light from the sun will pass through a quartz window having a 30-inch aperture onto flat mirrors mounted in the turret. The mirrors will direct the light down a long 320-foot tube to a spherical mirror at the bottom where it will be redirected upward to any one of five observation ports in the associated ground facilities.

Two design features should give the telescope exceptional flexibility and resolution. The first is in the mounting of the optical system. The entire optical system, including the 320-foot interior tube, and associated instrumentation, will rotate as the sun is tracked. This system will weigh approximately 150 to 200 tons.

The second feature is that the optical system and associated instruments will be placed in a vacuum. The purpose of the vacuum is to eliminate air turbulence. Turbulence can greatly affect the resolution of the telescope. An added advantage of the vacuum is the elimination of dust from optical surfaces that would degrade resolution and sensitivity.

In addition to research leading to the more precise prediction of dangerous proton showers, the new telescope will be used for research on a range of solar phenomena. Solar activities have a profound effect on the earth's weather, and on communication and detection systems. AFCRL scientists hope to obtain a clearer picture of solar-terrestrial relationships.

# structure of LIQUIDS

LtCol. Wm. H. Wyatt, Directorate of Chemical Sciences, AFOSR

A phenomenon which has intrigued chemists and physicists is the exact structural distribution of molecules in gases, liquids and solids. The goal is to describe the macroscopic or "real-life" properties of matter, in terms of molecular behavior. In a gas, the molecules are distributed in a random fashion; in a solid the molecules are usually fixed in a crystal lattice while liquids are intermediary between the random molecular distribution of gases and the crystal lattice of solids.

Dr. C. J. Pings and his associate Dr. Brian L. Smith, chemical engineers at Cal-Tech, are studying the structure of liquids under an AFOSR grant. They are using x-rays to probe the configuration of molecules in dense fluids using liquefied gases. One of the gases under investigation is liquid argon, an inert element. This simplifies the investigation, since the molecular forces can now be considered "two body" forces with the effect of "free" electrons eliminated.

In a narrow path, monochromatic x-rays are beamed upon a sample in a cylindrical beryllium tube. The rays are scattered both by the sample and the tube. A diffraction pattern is formed by the emergent x-rays and is recorded by photographic film or an electronic counter. Drs. Pings and Smith use a scintillation counter to measure the intensity of the diffracted beam as the counter is allowed to rotate around the axis of the specimen. A radial distribution function is calculated from these measurements.

This mathematical function represents the average configuration of the molecules under the conditions of the experiment. Although the radial distribution function does not give the position of

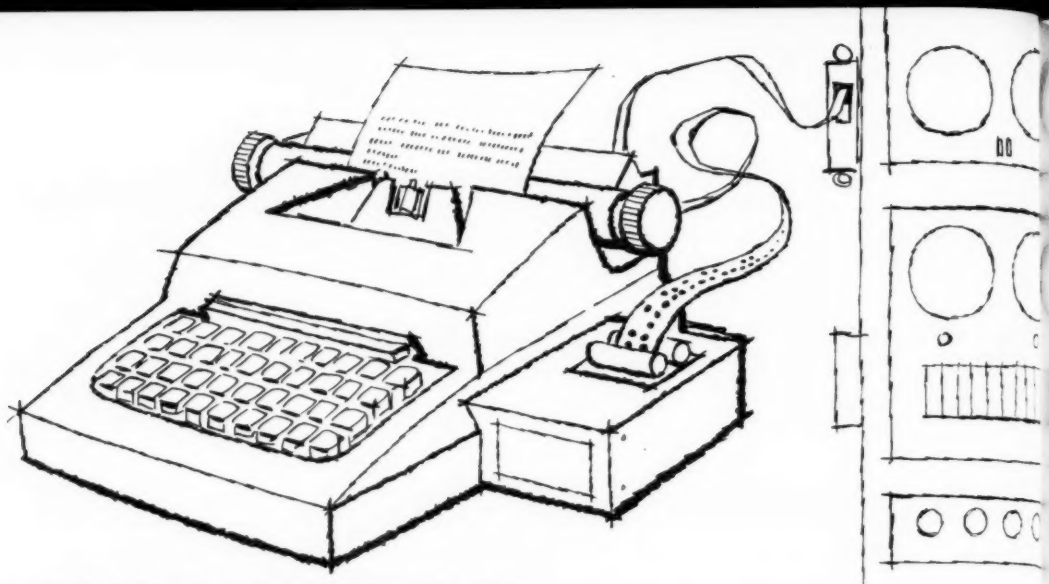
individual molecules, this function is a very useful tool for theoretical considerations. Hence, x-ray diffraction studies are used indirectly to confirm or refute a model, since the pressure and energy content can be estimated from the radial distribution function. From the pressure and energy content data, configuration models are computed which are compared with the various theoretical models. From this comparison, the correct model may be deduced for liquids.

A companion part of the research program is the study of the refractive index of liquefied gases. Refractive index measurements are used to calculate the "polarizability" of a molecule. This is related to the distortion produced in a molecule due to the presence of nearby molecules. This polarizability is directly related to the radial distribution function; therefore, these two comparable studies will complement each other in the investigation of molecular configuration in liquids.

With their system, they are able to measure x-ray diffraction over the angular range from -10 to +165°, temperatures can be varied from -195°C to about 200°C with measurement to $\pm$.05°C and pressure up to 1000 psi with measurement to one part in 20,000. Their techniques for handling diffraction data and their high precision instrumentation will allow greater accuracy than obtainable, previously.

While studying the structure of liquid nitrogen at 7 atmospheres and -193°C, their investigation showed that there is a first-order coordination shell containing 15 nitrogen molecules at a distance of 4.0 angstroms from a central nitrogen molecule. Their interpretation rejects the possibility of $N_4$ molecules or other multiple species which had been postulated from earlier investigations. This is a significant advancement in our knowledge of the molecular structure of liquids.

Understanding of the structure of liquids will be invaluable in designing propulsion and refrigeration systems as well as in cloud physics, since these systems and cloud physics depend upon the molecular behavior of molecules during heating, evaporation, condensing and freezing of fluids.



# REACTIVE TYPEWRITERS

Rowena Swanson, Information Research Division, AFOSR

"Ways out" of the information storage and retrieval problem can be made as enticing as new cures for colds. Everyone has or gets both, and almost everyone is willing to try at least one suggested remedy. We vary in our repeated credulity in cures.

It has been an aim of an AFOSR contractor, Mr. Calvin Mooers of Rockford Research Institute, Cambridge, Mass., to explore inexpensive solutions to information problems of research groups. He doesn't offer cures, but his suggestions have been found to be remedial. In 1960, Mr. Mooers described a "Tape Typewriter Plan"[1] which caught the imagination of many groups in this country and abroad. Presentations based on this paper were made in London, England; at the Gmelin Institute in Frankfurt, Germany; and in Paris, France. Applications of the plan have inspired the First International Symposium on the Use of Punched Tape Machines in Documentation and Library sponsored by the Euratom Joint Research Establishment (CCR) at Ispra, Italy, 28-30 May 1963. Another use of concepts in this paper is the recently instituted tape-sharing arrangement between ASTIA and OTS for catalog-card preparation by OTS.

Mr. Mooers' latest suggestions are embodied in AFOSR 2711, "Wanted: A Reactive Typewriter."[2] He proposes the use of remote computers by scientists, engineers, and librarians via telephone wire

connections to typewriters in the users' locations. These typewriters he calls "reactive typewriters."

What does this mean in terms of solutions to information problems? Mr. Mooers hypothesizes that the connection will permit direct recording and storage of text and data into computer memory and direct retrieval and printout of any part of it on demand. Direct numerical computations can be obtained. Descriptive and subject catalog information can be stored directly, and the store directly interrogated for alphabetic lists, merged lists, subject bibliographies, and catalog card production. Instructions to the computer to write programs to accomplish these manipulations can also be entered at the reactive typewriter.

Is the reactive typewriter available? Not yet. Is it a figment of imagination? No. Feasibility of the technique has been demonstrated in a computer-teleprinter-remote teleprinter hook-up. But hardware and software limitations exist. For symbol flexibility and readability, an 84-character keyboard capable of providing upper and lower case is desired; present teletypewriter equipment prints upper case. The typewriter should have direct wire access via commercial telephone, telegraph, or leased telegraph lines for communication with other typewriters as well as computers. Such connections must not tap or interfere with existing TWX and other channels. Computers must have interrupt and multi-programming features to permit reception from up to 1,000 customers and simultaneous service of up to 50 reactive typewriters, while preserving stored records without erasure. Computers must also have a capability for rapid transfer of storage blocks. Interrupt, multiprogramming, and rapid block transfer features are available in varying degrees in present computers. Software requirements center around a language sufficiently simple to permit any user to describe the operations he wishes the computer to perform and sufficiently powerful to accommodate problems in symbol manipulation. Mr. Mooers is working on such a language.

If the reactive typewriter became available, would its cost prohibit its use? Some estimates are given in the Mooers report and in a progress report published in the Communications of the ACM.[3] The typewriter plus associated customer equipment is ex-

pected to be realizable for $500. Leased telegraph wires cost about 10 cents an hour. If computers incorporated counters to monitor actual use time, storage of 55 lines of text would cost approximately 5 cents, or less. An average monthly cost not exceeding $50.00 is envisaged.

When will more information on this technique be available? Discussion on hardware and software aspects is in progress. It is hoped that a system can be demonstrated by the end of the year.

References:

1. "The 'Tape Typewriter Plan' - A Method for Cooperation in Documentation," by Calvin N. Mooers. July 60. AFOSR-TN-60-532, AF 49(638)-376.

It may be noted that, while the conventional tape typewriter is in wide use, its potential as a labor-saving device to libraries, for example, has not been fully utilized. Through cooperative effort, libraries could share the burden of cataloging documents duplicated in their collections, each member of the group providing the human input for a percentage of the total. Through tape exchange, each could have catalog data for the entire set. Other possible uses for exchanged tapes are discussed in the report.

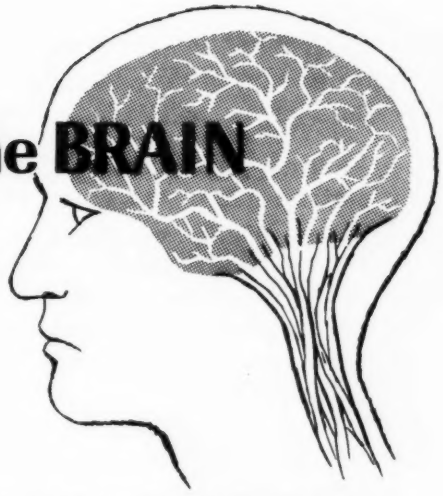
Card, list, and index preparation such as is contemplated on line with the reactive typewriter can be done now, off line, from paper tape input with such devices as the Itek Crossfiler.

2. "Wanted: A Reactive Typewriter," by Calvin N. Mooers. Oct 62. AFOSR-2711, Grant AF-AFOSR-62-377.

3. "The Reactive Typewriter Program, A Progress Report," by Calvin N. Mooers. Communications of the ACM 6:1, Jan 63, p. 48.

# CHEMICAL MESSENGERS in the BRAIN

Capt. B. D. Stollar(MC)
Biological Sciences Division, AFOSR



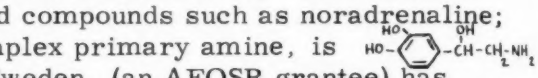
A masterful achievement in design, the brain is involved in every voluntary act of every one of our human operators, from planner to pilot. With its 10 billion nerve cell units and their interconnections, the brain mechanism includes extremely fine feedback controls and decoders of electrical signals which become meaningful to us as sensations, memory, reason and emotion; all of these contribute to the formation of every human decision.

A few years ago our mental image of this complex system would have been like a giant computer with electrical signals running to and fro, or a great telephone exchange. We are beginning to feel, however, that we may have been too quick to let our thinking be governed by such models that do not do justice to the subtlety of nature's designs. For example, we know that the brain is much more than an electrical network, but also involves perhaps hundreds of chemicals which have either local or very extensive effects on the working of the whole system.

Some classes of such compounds are called transmitters. They form the bridges for messages to travel from one nerve cell to the next; the electrical impulses themselves, which do pass along the nerve fibers, come to a stop where the fiber tips touch the next cell in sequence. There the action of the electrical impulse must release a small amount of a stored chemical. This chemical then affects the membrane of the next nerve cell and contributes to the inputs that determine whether or not that cell will fire.

There are many kinds of transmitter substances; the reason for this variation is not known. We do know of the role of acetylcholine as a transmitter between motor nerves and muscles, and in

recent years our knowledge of another family of compounds, the "amine transmitters", has been increasing.

The family of amine transmitters includes the well-known adrenaline, and chemically related compounds such as noradrenaline; the structure of the latter, a complex primary amine, is  Dr. A. Carlsson, of Goteborg, Sweden, (an AFOSR grantee) has contributed greatly to our knowledge of how these amines are formed, in the body, from the amino acid tyrosine. This process involves specific single-step enzymatic changes and the formation of intermediate compounds named "dopa" and "dopamine". A related transmitter compound is serotonin, derived through analogous enzymatic steps from the amino acid tryptophane. Both tyrosine and tryptophane are essential ingredients of a man's diet, and are among the twenty building blocks which make up proteins.

More recently, Dr. Carlsson and Dr. N. Hillarp, in conjunction with Dr. B. Falck of Lund, Sweden, have developed a new technique which promises to shed much light on the nature of the chemical transmission phase of brain function. This technique is based on the finding that when the amines are exposed to dry formaldehyde vapors, highly fluorescent condensation products are formed. Depending on which amine is present, the fluorescence may be bright green or yellow, and may develop rapidly or slowly. These observations are of importance in identifying the nature of the compound present.

It was subsequently found that if thin slices of freeze-dried brain (or thin sheets of any tissue containing nerve fibers) are exposed to dry formaldehyde vapor, the amine transmitters form the fluorescent complexes right in the spots they occupy in the tissue. When the treated slices are examined against a dark background under a fluorescence-detecting microscope, granules containing these transmitters shine brightly in brilliant green or yellow, depending on which transmitter is present. It has thus become possible to determine the precise location of the transmitter-containing granules in the nerve fibers, and to distinguish a variety of types of nerve cells on the basis of which transmitter they contain.

These bright granules light up the roadways of individual nerve fibers and their ramifications; they vividly demonstrate how fine nerve fibers invest other structures, even down to small blood vessels.

Since the transmitter granules disappear from nerve fibers that have been physically or chemically interrupted, it is now possible to use this method to trace out the pathways of particular sets of nerve cells in the brain.

It has also been found that there are clusters of cells, in different parts of the brain, which use particular transmitter compounds. The new fluorescence technique makes possible the precise location of these cells, and the plotting of a new kind of "amine transmitter map". This information leads to clues concerning localized function on a chemical level. The importance of this knowledge becomes even more apparent in view of the fact that we have empirically stumbled onto many chemicals which have profound effects on behavior and brain function. Some of these chemicals have been found to act by modifying the normal handling of the amine transmitter compounds. A full understanding of the chemical controls of the brain would make possible a much more refined and positive approach to influencing behavior and performance, and perhaps even capability.

While full understanding of the complex brain networks and their chemical controls is still a distant goal, techniques such as that of Drs. Carlsson and Falck mark positive steps toward that goal.

## AFCRL *notes*

AFCRL launched an Aerobee rocket carrying a 225-pound payload from White Sands Missile Range, New Mexico, during the week of 11 March to measure absorption of solar radiation by oxygen and other gases in the earth's upper atmosphere. The program was conducted under the direction of Adolph S. Jursa. Measurements took place over an altitude range of between 50 and 75 miles. The basic instrumentation was a spectrograph. The rocket experiment was part of a continuing AFCRL research program involving the composition and dynamic process of the upper atmosphere. Absorption and re-emission of ultraviolet

radiation from the sun plays a major role in maintaining the earth's heat balance and thus the process is of great interest to the climatologist. (Space Physics Laboratory)

High speed motion pictures in color of the human vocal cords have been taken for the first time at a frame rate of over 9,000 pictures per second by AFCRL scientists, Henry I. Soron, Sheldon B. Michaels, and Philip Lieberman. The best high speed motion pictures of sustained phonation previously available were black and white films at 4,000 pictures per second. These new color movies clearly show the onset and end of the phonation of brief transients that normally occur in speech. The area of the glottal opening of the vocal cords as a function of time will be measured from this film with the aid of a digital computer. Speech synthesis experiments will then be conducted to determine exactly what aspects of glottal activity must be preserved in advanced speech transmission systems in order to retain natural voice quality, speaker identification, and emotional cues. (Communication Sciences Laboratory)

## *FLARE INDUCED BOUNDARY LAYER SEPARATION ON A CYLINDER AT M=14*

Lt. Stephan J. Koob, Fluid Dynamics Facilities Laboratory, ARL

Boundry layer separation refers to the phenomenon by which the decelerated fluid particles in a thin boundary layer no longer adhere to the wall, but are forced outward and, with sufficient adverse pressure gradient, a dead region or reverse flow is produced.

Flow separation can be produced by any device which will cause a sufficiently large pressure rise and pressure gradient. Flares, flaps, steps, ramps and incident shocks can all be classified as such mechanisms.

Separation has many effects, some of which are desirable. Just as separation at low speeds affects the design and performance of missiles and aircraft, hypersonic boundary layer separation also affects design geometries by reducing heat transfer rates in the separated region, increasing the heat transfer rates at reattachment and inducing boundary layer oscillations and load shifts.

The theoretical prediction of separated flow variables at hypersonic speeds is complicated by shock-boundary layer interaction,

real gas effects, significant interaction between viscous and non-viscous flows, nonlinear effects of high Mach number, and the increased importance of pressure gradients normal to the body. These complications have fustrated attempts to predict separation and resulting boundary layer steadiness, surface pressure distribution and heat transfer rates. Thus, experimental data must be heavily relied upon, and empirical results incorporated if the separation phenomena is to be judged either acceptable or undesirable by the aerospace vehicle designer.

The cylinder-flare configuration is of particular interest because of its utility for drag and stability control of missiles. A research effort was initiated at ARL in 1962 for the purpose of obtaining experimental data on the flow varibles in the separated region near a cylinder-conical flare junction. Tests have been run at M=14 in the ARL 20-inch hypersonic wind tunnel on a cone-cylinder-flare model (see Fig 1) with a $20^{o}$ flare and a $40^{o}$ flare. Surface pressure data and schlieren photographs indicate that the $20^{o}$ flare does not cause

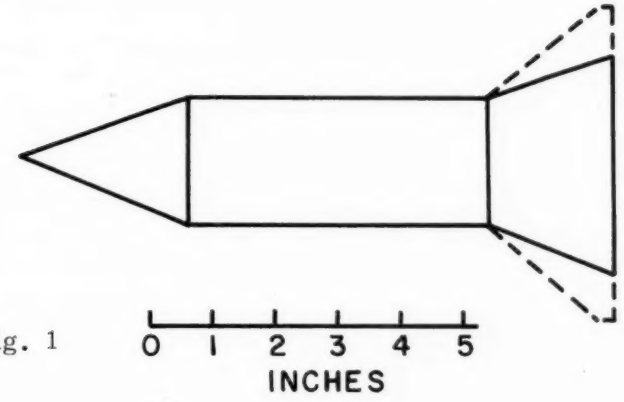
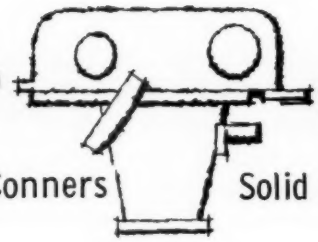



fig. 1

separation; however, the $40^{o}$ flare will induce separation.

These tests will be continued in the 30-inch hypersonic tunnel at M=18 to study the effect of Mach number on this phenomenon. Not only is this type of investigation applicable to the stability and control of missiles, but there is some indication that at extreme re-entry velocities where oscillations occur, probably a "footprint", i.e., a detection of the shape of the body on a re-entry vehicle, could be determined from the scintillations resulting from the high heating associated with re-entries. Should this prove true, there is the possibility that a manual of "footprints" of various configurations could be determined and fed into a computer to aid in the detection of decoys versus live warheards as they enter the atmosphere.

# better  pictures ?

LtCol. Ralph W. Conners | Solid State Sciences Division
AFOSR

The results of an investigation by Professor F. C. Brown of the University of Illinois under Air Force Grant AF-AFOSR 62-215 will give a better understanding of the photographic processes and lead to better pictures of much greater detail. This will give the Air Force better reconnaissance pictures and will, in all probability, improve the quality of identification and even passport pictures.

This investigation has revealed the band structure of the photographic materials silver chloride and silver bromide. These experiments were performed on crystals of very high purity. They include millimeter-wave cyclotron resonance, magnetoresistance and optical absorption at low temperature. It has been found that the characteristic violet absorption and photosensitivity of the silver halides is due to indirect transitions between valence and conduction bands accompanied by the emission and absorption of phonons. The maximum energy of electrons in the uppermost filled band occurs at points on the boundary of the Brillouin Zone, whereas the conduction band is of standard form with a minimum at the center of the zone. (This is just the inverse of the situation in germanium and silicon where the minimum in the conduction band occurs at the boundary of the zone.) Furthermore, a free electron in AgCl is surrounded by a lattice polarization due to the ionic character of the lattice. This gives rise to so-called polaron effects which are appreciable but not large enough to greatly reduce the mobility of electrons - a mobility important in photographic and photoconductive processes. In fact, it appears that polaron effects help to explain the observed high quantum efficiencies for the production of free electrons and holes by light rather than the formation of bound electron-hole or exciton states. The unique and complicated valence band structure of the silver salts arises partly because of the closed electronic shells of the noble metal ion and partly because of the high symmetry of the lattice. The results of this work on pure crystals are important in understanding the role played by impurities in sensitized silver halides and also in looking for photo-properties in other substances.

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